10/564021

IAP20 Rec'd PCT/PTO 09 JAN 2006

HOLDER FOR FLAT WORKPIECES, IN PARTICULAR SEMICONDUCTOR WAFERS FOR MECHANOCHEMICAL POLISHING

The present invention is related to a holder for flat workpieces, in particular semiconductor wafers, for mechanochemical polishing according to the patent claims 1, 5 and 6.

In the manufacture of semiconductor chips, the so-called wafers are planarized or abraded by means of suitable devices. One known method is mechanochemical polishing (shortly CMP). In this method, the wafer is polished with a defined contact pressure force with the aid of an etching and also abrasive polishing agent on a polishing cloth of plastics under rotatory and optionally oscillatory movement of the polishing cloth and the wafer. During the polishing process, the polishing agent (slurry) flows onto the polishing cloth and forms a layer between cloth and wafer. The slurry used consists of a chemically aggressive solution, into which particles, like silica e.g., are added in a colloidal suspension.

During processing, the wafers are held by a holder or carrier and pressed by it against the machining surface for polishing. The holders are connected to a spindle of a driving apparatus, which is height-adjustably mounted in order to move the wafer against the machining surface.

It is known to realise the lower holding surface of the holder by a steel plate, which is provided with bores, in order to keep the wafer on the holding surface by a vacuum during transportation. The holding surface is coupled to the spindle of the working machine via an universal joint in order to attain an uniform contact

pressure. Such a holder has become known from DE 100 62 497 A1, for instance. Further, from DE 197 55 975 A1 it has become known to height-adjustably guide a holding plate in the holder and to arrange an annular closed membrane between a supporting portion and the holding plate. The sealed inner space of the membrane is selectibly connected to atmosphere or vacuum or to a fluid source, respectively. With the aid of pressure and vacuum, adjustment of the holding plate with respect to the holder is performed.

A different form of realisation of the holder provides a membrane from a flexible material, which is disposed below the holder. The membrane transfers the contact pressure to the taken-up wafer. From US 5,964,653 it has also become known to form three chambers with the aid of a holding plate and a membrane which is attached on the bottom side of the holding plate, namely a central circular chamber and two annular chambers which are concentrically arranged around the central chamber, each one thereof being in connection with a channel in the spindle. A pressurised fluid source is connected to the three channels via a rotational transducer, in order to control the contact pressure applied to the wafer. Even in this, the holder is coupled to the driving spindle of the driving apparatus via a universal joint. A similar system has become known from WO 02/004172 A3. It uses two membranes lying upon another, between which a different pressure is applied to three chambers which are formed above the pressing surface.

The present invention is based on the objective to provide a holder for flat workpieces, in particular for mechanochemical polishing of semiconductor wafers, by which conformation to the desired abrasion profile of the wafer can be attained in a simple manner.

This objective is resolved by the features of patent claims 1, 5 and 6.

The holder according to the invention after patent claim 1 provides a relatively thin flexible membrane on the bottom side of a holding plate, which forms a plurality of concentric ring chambers with the bottom side of the holding plate. In the housing of the holder, a number of on-off valves is disposed corresponding to the number of the ring chambers, which are all in common connected with a channel in the spindle. The channel in the spindle is connected to a so-called rotational transducer in its upper region, i.e. with a stationary supply of pressurised fluid. Optionally, connection to vacuum is possible. With the aid of the on-off valves, it is possible to apply individual pressures to a high number of ring chambers, depending from the desired profile that is to be abraded from the wafer surface. In fact, it is conceivable to provide proportional valves in place of the on-off valves, so that different pressures can be applied to the ring chambers at the same moment. However, it is not possible to accommodate a plurality of proportional valves in the housing of the holder or carrier, due to the sizes thereof. Naturally, the housing is restricted in its dimensions. Thus, the supply to the on-off valves requires only one channel in the spindle, the pressure in the ring chambers being adjusted consecutively in this, which requires a certain time.

For the rest, it is conceivable as an alternative to provide one supply line per ring chamber via the driving spindle, the supply lines in the driving spindle being in connection to a rotational transducer and being triggered by proportional valves in a stationary arrangement. Thus it is possible to adjust the pressure profile parallel in time via the ring chambers. The expenditure for the driving spindle with the

rotational transducer is significant. Furthermore, each holder needs a special driving spindle, depending on its construction.

Electric signals are required for triggering the on-off valves in the holder. They are transmitted into the interior of the housing from the outside via a slip ring arrangement.

According to one embodiment of the invention, the holding plate has a distribution channel system, which is in connection to the ring chambers via vertical bores. The on-off valves can be mounted directly on the top side of the holding plate and be connected to the distribution channel system, so that transfer lines or tubes can be omitted. It is also conceivable to extend the channel in the driving spindle up to the interior of the holding plate, when the driving spindle is in direct connection with the top side of the holding plate. In this case, the supply of the pressure medium to the on-off valves can take place without lines.

According to a further embodiment of the invention, pressure sensors are disposed in the housing, which are connected to the ring chambers and the output of which is guided to the exterior by means of a sensor line via the rotational transducer device. The pressure sensors are manometric switches, e.g., which are adjusted to a predetermined value and which indicate whether the pre-set value has been reached or exceeded, respectively. Thus, the pressure in the individual ring chambers can be permanently monitored. Furthermore, it is possible to detect damages in the membrane. In order to keep the rotational transducer device small, all the outputs of the pressure sensors can be laid on the output lines. Because the individual ring

chambers are serially provided with pressure, as has been mentioned, the signal value generated by the pressure sensors can be detected synchronously, so that the pressure detected at a time is valid for that pressure chamber the on-off valve of which has just been triggered. When manometric switches are used as pressure sensors, they can be intercepted only when in all the chambers there is a pressure which is greater than the switching pressure for the manometric switches. For this reason, a permanent monitoring of each individual ring chamber is no more possible, however.

It is conceivable to attach the rotor of a slip ring transducer on the driving spindle, and the stator on a bearing housing for the spindle. Another form of realisation of the present invention provides for this purpose that the ceiling wall of the housing is stationary, in contrast to conventional constructions. On the bottom wall of the stationary ceiling wall, a stator of a slip ring arrangement is attached. On the spindle or a bearing spigot of the driving spindle, which is fixed to the holding plate, a rotor of the slip ring arrangement is attached on the outer side. The slip rings are in connection with the on-off valves and the signal outputs of the pressure sensors, respectively, via controlling lines. The slip ring arrangement is arranged inside the holder housing in a protected manner and it is not necessary to guide a plurality of electric lines into the interior of the housing via a cable passing through the spindle.

In the resolution according to the invention according to patent claim 5, a plurality of annular flat recesses is provided on the bottom side of the holding plate, disposed concentric to the spindle axis, which are preferably formed as being flat concave or grooved, respectively. They are selectively connectible to a pressure source or to vacuum, via a pressure distribution device in the interior of the housing of the holder

or via the driving spindle. It has already been pointed out in the beginning that holders for wafers must also transport them, which is normally accomplished by negative pressure. The negative pressure can be transferred directly to the wafer by holes in the membrane or in the holding plate. In the invention, an aspirating effect is generated with the aid of the flexible membrane, wherein only one ring chamber or certain ring chambers are provided with vacuum, depending on the triggering, in order to exert an aspirating effect on the wafer. The ring chambers are rather flat, at most 1 to 2 mm in depth.

In the resolution according to the invention according to patent claim 6, the outer diameter of the membrane which is held on the bottom side of the holding plate is greater than that of the workpiece or the inner diameter of the retaining ring, respectively. In order to avoid any slipping of the wafer with respect to the holder during polishing, it is known to provide the holder with a so-called retaining ring, the inner diameter of which is about the same as the outer diameter of the wafer. It is also known to realise the retaining ring adjustable in its height with respect to the holder and to provide a suitable adjustment device, a rolling membrane or the like for example, by which the retaining ring is pressed against the polishing cloth with more or less contact pressure when the wafer is pressed against the working surface with the aid of the holder. In the realisation according to the invention, the outer edge of the membrane forms a pressure chamber together with the holding plate, which is disposed above the lower portion of the retaining ring and by which a pressure in the desired height is exerted on the retaining ring or on another ring disposed in this region, in order to apply a specific contact pressure on the polishing cloth. The wafer is pressed into the polishing cloth for a certain amount during polishing. Therefore, a stronger abrasion is hardly avoidable in the edge region of the wafer when no counter-measure is taken. Now, with the aid of the outer ring chamber, it is achieved that the polishing cloth is pressed down for a desired amount

in the region adjacent to the edge of the wafer. When the polishing cloth is pressed down more strongly, only very slight or no abrasion takes place at the edge region of the wafer. Thus, the amount of abrasion at the edge region of the wafer can be adjusted to a desired value with the aid of the outer ring chamber of the membrane.

It is known to move the holder with the taken-up wafer via a so-called electric axis to a lower point above the working surface at first during the polishing process, so that the wafer is situated in a very small distance to the surface of the polishing cloth, for instance in a distance of less than 1 mm. In the movement to such an endpoint, the vertical or axial slack of the spindle has to be taken into account, which is not zero, of course. Moreover, the polishing cloth looses in height through wear after a certain period during the polishing process, so that the distance between the bottom side of the wafer and the top side of the polishing cloth becomes greater in the course of time, and the wafer has to pass through a greater stroke in order to be pressed against the working surface. However, the contact pressure on the polishing cloth has to adopt a desired value, regardless of these variables. For this purpose, one embodiment of the present invention provides that the membrane has several annular extension bellows, concentric to the spindle axis, on its top side, which are fixed on the bottom side of the holding plate and which predetermine the maximum height of the stroke of the membrane upon pressure in the ring chambers. The extension bellows enable a relatively big stroke of the membrane, so that the stroke generated with the aid of the membrane is in every case greater than the maximum vertical tolerance of the driving spindle and the maximum permissible abrasion of the working surface taken together. Thus, with the aid of such a construction, a path-independent polishing force can be realised in a large region of stroke.

The annular extension bellows as annular elevations having an annular slit on the top side can serve to fix the membrane on the holder plate at the same time, the extension bellows or elevations, respectively, being accommodated in annular recesses on the bottom side of the holding plate. The elevations or extension bellows accommodate clamping rings having projections that jut out to the upside in diametric distances, which extend upward through the slit and which are drawn against the bottom of the annular recesses by means of screws in the holding plate. Through this, the extension bellows are fixed on the holding plate. Further, the clamping rings serve to tighten the slits and to separate the ring chambers from each other. In this, the extension bellows or the annular elevations, respectively, form a first kind of ring chambers in the interior and a second kind of ring chambers between adjacent elevations, which are each one connected to the pressure distribution device via at least one vertical bore.

According to another embodiment of the present invention, the holding plate consists of three single plates lying upon each other, the lower one of which holds the membrane and a distribution channel system is formed between the middle and the upper single plate, which is connected to the individual ring chambers of the membrane on the one hand and via vertical bores in the upper single plate with the pressure distribution system and the on-off valves, respectively, on the other hand.

Upper and middle single plate can be directly connected to the spindle or a spindle spigot, respectively, via a screwing joint, whereas the lower single plate is screwed on at least one block which is seated on the upper single plate and is separately detachable with accommodated membrane. Because the membrane is a wearing part, only the lower single plate has to be detached in order to replace the membrane. In

doing this it is possible to actuate the screws through corresponding holes in the ceiling portion of the housing, which are each one guided through one block for the purpose of screwing them with a threaded bore in the lower single plate. Because the lower radial portion of the retaining ring is usually disposed below the holding plate and in the case of the present invention also below the outer edge of the membrane, respectively, it is advantageous when the holding ring for the retaining ring is realised as a separately unscrewable annular component, which is at first removed when the bottom single plate is to be detached. The described blocks, which are screwed together with the upper single plate, can also serve for the mounting of the housings of the pressure sensors, vertical bores in the holding blocks forming channels for connecting the pressure sensors to the distribution channel system in the upper and middle single plate at the same time. Through this, a line or tube connection to the individual ring chambers becomes unnecessary for the pressure sensors also.

Another embodiment of the present invention provides that the membrane has a hole in its centre, which is connected to an additional channel in the spindle via a bore in the holder plate, the additional channel being selectively connectible to a source of pressure or vacuum. By applying a vacuum it can be detected whether there is a wafer closely to the membrane. Thus, feedback is attained if a wafer has actually been taken up after a taking-up operation. During the polishing operation, a certain pressure is applied on the central bore, which prevents that there is no wear-off in the region of the hole. Thus, the fluid pressure compensates for the lack of the membrane in the region of the hole.

With the aid of the holder according to the present invention, it is possible to establish a polishing or abrasion profile, respectively, after survey of the surface of a wafer, according to that survey. It is known to survey the layer thickness of the polished layer during the polishing operation. Thus, in the invention it is possible to readjust the polishing and wear-off profile. In the various machining processes of wafers, different wafer surfaces and as a consequence different requirements for the abrasion profile result, of course. Even here, suitable adjustment can be performed in the present invention.

Realisation examples of the invention are hereinafter explained in more detail by means of drawings.

Fig. 1 shows a cross section through a schematically represented holder according to the invention.

Fig. 2 shows a part of the holder according to the invention on a polishing dish, immediately before a polishing process.

Fig. 3 shows a representation similar to that of Fig. 2 with a taken-up wafer resting on the working surface.

Fig. 4 shows the contact pressing of the wafer against the working surface, the retaining ring taking a first position.

Fig. 5 shows a representation similar to that of Fig. 4, the retaining ring taking a second position.

Fig. 6 shows a cross section through the holder according to the invention with all details.

Fig. 7 shows a representation similar to that of Fig. 6, some details being omitted, however.

Fig. 8 shows the top view on the holder according to Fig. 6 and 7 with removed ceiling portion.

Fig. 9 shows a representation similar to that of Fig. 7, but with disassembled assembly parts.

Fig. 10 shows the membrane of the holder according to Fig. 6 to 9.

Fig. 11 shows a magnified detail of the holder according to Fig. 6 or 7 in the edge region.

In Fig. 1, a holder 10 for semiconductor wafers is schematically represented. It has a housing with an annular wall portion 12, a disc-shaped ceiling portion 14 and a holding plate 16 in the lower region of the housing, which is constituted by a lower plate 18 and an upper plate 20, which are lying upon another and are fixedly connectible to each other. A driving spindle 22 is connected to a suitable driving apparatus (not shown) for rotation and optionally linear horizontal movement and is guided into the interior of the housing of the holder 10 via the ceiling portion 14 and is fixedly attached to the upper plate 20. The ceiling portion 14 is stationary, as indicated at 24. This will be dealt with further below.

A holding ring 26 is disposed on the inner side of the wall portion 12 with a portion drawn towards the inner side, and between this portion and a shoulder of the wall portion 12, a bellow 28 is disposed. The holding ring 26 is pre-tensioned towards the upside against the bellow 28 by a spring 30. The holding ring 26 bears a retainer ring 32 on its bottom side, which extends radially towards the inside and extends below a portion of the lower plate 18.

The lower plate 18 has six annular flat deepenings of different width on its bottom side, disposed concentric to the spindle axis. The deepenings, which are lens-like in their cross section, are relatively flat and have a maximum depth of 1 to 1,5 mm, e.g. A circular membrane 36 is disposed on the bottom side of the lower plate 18. Through a suitable realisation and recesses in the plate 18, bridges 38 of the membrane 36, which form flanges 40 on the top side, are bound to the plate 18. Through this, the membrane is kept fast on the lower plate 18. In this way, the deepenings 34 and the membrane 36 form six annular chambers MK1 to MK6. Each chamber MK1 to MK6 is connected to an on-off valve 44 in the housing of the

holder 10 via at least one vertical bore 42 in the plates 18 and 20. In Fig. 1, the on-off valves are only indicated as symbols.

A first axial channel 46 in the spindle 22 is in connection with a stationary line 50 via a rotational junction 48, which line 50 can be connected to a not shown controlled pressure source or optionally to vacuum. The channel 46 is guided outward in the interior of the housing of the holder 10 and is connected to a line 52, which is connected to all the inputs of the on-off valves 44. The pressure which is present in the line 50 is transferred to that chamber MK1 to MK6 of which the on-off valve is opened. In this way it is possible to gradually build up a desired pressure in the individual chambers MK1 to MK6. The triggering of the on-off valves 44 takes place via a rotational transducer 54, by means of slip rings, for instance. A rotor 56 of the rotational transducer 54 is fixedly connected to the spindle 22, and two stator portions 58 co-operate with the rotor 56. In the present case, two times 5 brushes each co-operate with ten slip rings, eighth slip rings being needed for triggering the seven on-off valves 54. The electric junction of the stator 58, which is connected to the ceiling portion 14, is not represented here. In the present case two cables are required, which are guided to the stator portions 58 through a corresponding leadthrough in the ceiling portion. In the case that only one single stator is provided, one single cable will be sufficient.

In Fig. it can be further recognised that a semiconductor wafer 60 clings to the bottom side of the membrane 36. It is delimited in its lateral position by the retaining ring 32, the inner diameter of which is minimally greater than the outer diameter of the wafer 60. One further recognises in Fig. 1 that the diameter of the membrane 36 is greater than the diameter of the wafer 60 and that it extends about a part of the

retaining ring 32 with a back-set portion. Thus, a further chamber MK7 is formed above the retaining ring 32, which is also in connection with an on-off valve 44, via a channel 62.

In another part of the housing of the holder 14, seven pressure sensors 64 are disposed, which are connected to the pressure chambers MK1 to MK7 via vertical bores 66. The pressure sensors 64 detect the pressure in the pressure chambers MK1 to MK7. Via the slip ring transducer 54, the signal outputs of the pressure sensors 64 are in connection with an external control device (not shown) which evaluates the signals. Thus, it can be determined whether the desired pressure is present in the chambers MK1 to MK7. As the case may be, readjustment may then be performed. Furthermore, it can be determined with the aid of the pressure sensors whether the membrane 36 works correctly. Certainly it is possible to guide individual single lines from the pressure sensors 64 to the exterior via the rotational transducer 54. However, this would require eight lines all in all. In the present case, only two slip rings are still at disposition. Therefore, all the signals of the pressure sensors 64 are guided to the exterior via the two lines. However, because the pressure chambers MK1 to MK7 can also be provided with pressure only consecutively when a varying pressure is desired, it is sufficient to measure this pressure synchronously by means of the pressure sensors 64.

In the spindle 22, a second channel 64 is provided, which is connected to a line 66 via the rotational junction 48, said line 66 being also connectible to a pressure source. Inside the housing, the channel 64 is connected to the bellow 28. As a consequence, the retaining ring 32 can be adjusted in the height with the aid of the bellow 28.

In Fig. 1 it can be further recognised that the membrane 36 has a hole 68 in its centre, which is in connection to a third channel 70 in the spindle 22 via vertical bores in the plates 18, 20. Via the rotational junction 48, the channel 70 is connected to a line 72, which leads to a pressure source or optionally to a vacuum source. The lower plate 18 is deepened at 74 above the hole, in a tapered fashion. The deepening is connected to the vertical bores. As a consequence, a negative pressure can be generated at the hole 68 in the case of vacuum. Through this it can be determined whether a wafer 60 has been taken up by the holder 10. In the case of polishing, pressure is applied to the hole 68 in order to compensate for the absence of the membrane 36 in this region.

In the following, the operation of the holder according to Fig. 1 will be explained in conjunction with Figs. 2 to 5.

When the holder 10 is lowered down on a pre-positioned wafer, the wafer 60 lying centrically inside the retaining ring 32, a negative pressure is generated on all or certain ring chambers MK1 to MK6 via line 50 and on-off valves 44, so that the wafer 60 is held by an aspirating effect, because the membrane 36 deflects itself partly or completely into the flat deepenings 34. In this, the spring 30 pushes the retaining ring 32 into its uppermost position, and the bellow 28 is without pressure. The holder 10 transports the wafer 60 to a polishing dish, which is indicated in Figs. 2 to 5 at 74. It bears a polishing cloth 76 and is rotationally driven around a not shown axis, as is per se known. Above the polishing dish 74, the holder 10 is lowered to a point shortly above the top side of the polishing cloth 76 by the spindle 22, in a distance of 1 mm or less, for instance. This is indicated in Fig. 2 with respect

to wafer 60. Thereafter, the bellow 28 is provided with pressure via line 72, the pressure providing for shifting the retaining ring 32 into close contact with the polishing cloth 26. It should be mentioned that in this the polishing dish 74 as well as the holder 10 are set into rotation. By pressurising the chambers in MK1 to MK6, the membrane 36 is now moved downward, a pressure profile according to the corresponding pressure distribution in the individual chambers acting on the wafer 60, in order to obtain a varying abrasion of the wafer 60. As has bee mentioned already, the pressure in chambers MK1 to MK6 is built up gradually, because it is supplied via only one single line 50 and the latter is connected to a controllable pressure source, a proportional valve, e.g. With the aid of the pressure sensors 64, it can be determined whether the respective pre-set pressure has been actually reached.

From Fig. 4 one can recognise that at corresponding pressure, the wafer 60 is pressed into the polishing cloth 76 for a small amount. When the retaining ring 32 remains in the indicated position, an increased abrasion on the edge of wafer 60 takes place. This may be desired or even not desired. If it is wanted to avoid the increased abrasion or even attain a reduced abrasion at the edge, a corresponding pressure is generated in the chamber MK7 as shown in Fig. 5, through which the retaining ring 32 compresses the polishing cloth 76 for a certain amount and moves the polishing cloth off from the outer edge of the wafer 60 by doing so.

After completion of the polishing process, chambers MK1 to MK7 are released from pressure and thereafter certain chambers MK1 to MK7 are set under vacuum in order to lift the wafer from the polishing dish 74. In this operation and also in the transportation to the polishing dish, a vacuum is applied via line 66 on the hole 68 of the membrane 36, through which is examined whether the wafer sits actually close

to the holder 10. During the polishing operation, in contrast a small excess pressure is applied to the hole 68, through which is prevented that a decreased abrasion takes place on the wafer 60.

Before a wafer is subjected to a polishing process with the aid of the described holder, the wafer has to be taken up from a pick-up position. In this, front side and backside of the wafer are often wetted with slurry and/or water. The following steps are performed for taking up the wafer:

The inner ring chamber MK1 is filled with a predetermined pressure by the not shown control device. It is waited until feedback is given by the assigned pressure sensor.

Thereafter, the control device triggers the on-off valves 44 such that the ring chambers MK1 to MK6 are filled with a predetermined pressure one after the other with a delay in time, i.e. from the inner to the outer side. By doing so, liquid staying on the wafer surface is displaced towards the outside.

After filling the outer ring chamber MK6, all the ring chambers MK1 to MK6 are released from pressure. Furthermore, a vacuum is applied to the hole MK0 or 68, respectively.

After a corresponding delay time, the membrane chambers MK2, MK3 and MK4 are given vacuum, in order to have the wafer adhere on the membrane 36.

After a repeated delay, the holder lifts the wafer off from the pick-up position and transports it to the polishing apparatus.

By means of Figs. 6 to 9, a construction of a holder is described in more detail, similar parts like in Figs. 1 to 5 being provided with equal reference numerals, even though they are not realised to be totally identical in construction.

In Figs. 7 and 9 one can recognise that the spindle 22 is mounted in a housing 80. Further one can recognise that the ceiling portion 14 of the holder 10 is fixedly attached to the housing 80, therefore it does not rotate with the remaining parts of the holder 10. A spigot is 82 is fixedly screwed together with the spindle 22, which is rotatably mounted in the housing 80 by means of roller bearing 84 and extends towards the downside. The rotor 56 of the slip ring arrangement is seated on the spigot 82, which can be recognised particularly well in Figs. 7 and 9. In the latter figures the stator, which is connected to the ceiling portion 14, is not shown. The slip arrangement 54 is located inside a shell 86, by which is prevented that abraded material from the slip ring arrangement 54 spreads inside the housing of the holder 10.

In Figs. 6 to 9 it can be recognised that the holding plate 16 according to Fig. 1 is composed by three single plates 88, 90 and 100. The plates 90, 100 are screwed together, as is indicated at 102. Together, they form a distribution channel system, about which will still be dealt with later. As can be seen from Fig. 6, the unit from plates 90 and 100 is screwed together with the spigot 82. One of the screws is indicated as 92 in Fig. 6. With the aid of screws 94, two upright standing blocks 96 are fixed on the top side of the upper single plate 100 (also to be recognised in Fig. 8). They are approximately trapezoid in their cross section. The blocks 96 serve for the attachment of pressure sensors, which are designated with 98 in Fig. 8. In total seven pressure sensors 98 are mounted, corresponding to the pressure sensors 64

after Fig. 1, every two being disposed on top of each other, except pressure sensor 98 in Fig. 8 at the upper side at right. In the blocks 96 vertical channels are formed (only indicated in dashed lines in Fig. 8), which are connected to the input of the pressure sensors 98 and which run downside to the plate unit 90, 100 to a part of the not further shown distribution channel system, in order to be connected to the ring chambers (MK1 to MK7 in Fig. 1). The electric outputs 106 of the pressure sensors 98 go to the slip ring arrangement 54, all being connected together, so that only two slip rings of the slip ring arrangement 54 are occupied by them.

In Fig. 8 it can be further recognised that seven on-off-valves 108 are attached on the upper single plate 100. Input as well as output of the on-off valves 108 are connected to the distribution channel system between plates 100 and 90, so that they can be connected to a source of pressure or vacuum, as indicated in Fig.1.

Plate 90 has an axial collar projecting towards the upside, which extends through an opening of the upper plate 100 and which has a bore 110.

On the bottom side of the lower plate 88, the membrane 36 is attached. The membrane 36 can be recognised better in Fig. 10. The membrane 36 has a thin flat portion 112, which is realised in a manner like an extension bellow on its edge, as represented at 114. On the top side of the flat portion 112, three annular extension bellows 114a are formed, which are disposed concentrically to the axis of the spindle 22. They have an annular slit 116 in their upper portion. In conjunction with Figs. 6 to 9 one can recognise that the outer diameter of the flat portion 112 is slightly smaller than the inner diameter of the retaining ring 32. Between the

extension bellow edge 114 and the outer annular extension bellow 114, an annular ply 118 is formed. The mounting of the membrane 36 on the lower plate 88 can at best be recognised in Fig. 11.

The lower plate 88 has three annular concentric recesses 120, which accommodate the annular extension bellows 114a. The annular extension bellows 114a accommodate annular ledges 122 on their part, which are formed as being reversely T-shaped in section and which are introduced via the slits 116. In perimetric distances, the upper portion of the annular ledges 122 is screwed on in the lower plate 88, as can be recognised at 124 in Figs. 7 and 9. Furthermore, the upper portion has a vertical bore 126 in perimetric distances, which runs out into an annular groove 128 of the annular ledge 122. Towards the upside, the bore 126 is directed towards a bore 130 in the lower plate 88, which is on its part in connection to the distribution channel system of the plates 90, 100, which is not shown in detail, in order to apply optionally pressure or vacuum to the bore 126. Through this, that condition is also transferred to the interior of the extension bellow 114a. Through the annular ledge 122, sufficient sealing with respect to the plate 88 is achieved.

On the edge of the plate 88, a somewhat greater annular recess 132 is formed, which accommodates the extension bellow 114 as well as the annular ply 118. A first annular ledge 134, which is L-shaped in its section, grasps below the plate 118. It can be pressed against the bottom of the recess 132 by not shown screws. Between the ply 118 and the extension bellow edge 114, there is seated a ring 136, reversely L-shaped in its section, which is pressed against the bottom of the recess 132 by the ring 134 and thus fixes the extension bellow edge 114 by clamping. In this way, an outer ring chamber is formed between the annular extension bellow 114a and the ply

118, corresponding to the ring chamber MK6 according to Fig. 1. Between the ply 118 and the extension bellow edge 114 an outermost chamber is formed, corresponding to the chamber MK7 according to Fig. 1. Whereas the chambers MK1 to MK6 face the flat portion 132 of the membrane 36, the outermost chamber MK7 acts on the retaining ring 32. The somewhat retracted portion of the membrane 36 below the junction of the ply 116 and the extension bellow edge 114 rests on the top side of the retaining ring 32, as can be recognised particularly well in Fig. 11.

The clamping rings 122, 134 have a mortise 135 on the bottom side, through which a fluid distribution about the perimeter of the ring chamber takes place.

As a consequence, the ring chambers MK1 to MK6 are realised inside the annular extension bellows 114a and between the extension bellows 114a with the aid of the membrane 36. As is represented in Figs. 6, 7 and 9, for instance, the ring chambers between the extension bellows 114a are also connected to a vertical bore 140, which is itself connected to the distribution channel system of the plates 80, 100.

As can be recognised from Fig. 9, the membrane 36 can be connected to the plate 88 in the described manner, before the latter is mounted on the holder 10. The mounting takes place with the aid of longer screw bolts 142 (see Fig. 9), which are guided through a sleeve 144 inside a block 96 and through corresponding openings of the plates 90, 100, in order to be screwed on in a threaded hole 146 on the top side of the plate 88. The threaded portion of the screw bolts 142 can sit in a threaded bore of the upper plate 100, in order to hold the former ones. The actuation of the screw bolts 142 takes place via an opening in the ceiling portion 14, as can be recognised

on the left side of Fig. 9, where a so-called hexagon socket screw key is indicated at 148. After screwing on, the hole can be closed by a cap 150.

In Fig.9 it can be further recognised that holding ring 26 and retaining ring 32 are pre-mounted as a single unit and can be laterally fixed on an annular assembly piece 154 with the aid of headless screws 152, which is height-adjustably mounted in the interior of the housing and is actuated by the membrane 28. Thus, the retaining ring 32 can be shifted towards the downside, whereas it is pre-tensioned towards the upside by a spring which can not be recognised in Fig.9. By simply removing holding ring 26 and retaining ring 32 and by simply screwing off the lower plate 98, the membrane 36 can therefore easily be replaced. The membrane 36 is a wearing part and it has to be replaced from time to time.

One recognises from the formation of the membrane 36 that it can perform a relatively large stroke when the chambers MK1 to MK7 are accordingly pressurised, by reason of the formation of the clamped extension bellows 114a and the extension bellow edge 114. The individual ring chambers MK1 to MK7 are separated from each other and are connected to the on-off valves 44 (Fig. 1) or 108 (Fig. 8), respectively, via the distribution channel system. The pressure sensors 98 as well as the on-off valves 108 are not connected to lines, but are connected to the lines or channels 46, 64 (Fig. 1) in the spindle 22 through immediate connection with the distribution channel system of the plates 90, 100 or a corresponding bore in the spigot 82, respectively.

In the case that the retaining ring 32 is screwed to the holding ring 26 with the aid of a screw 156, as is shown in Fig. 11, not even releasing the holding ring 26 is necessary in order to remove the lower plate 88. The retaining ring 32 is also a wear part and thus it can be replaced in a simple way.

In Fig. 6 it can be recognised that each two cables 160, 162 are connected to the ceiling portion 14 of the holder 10 via corresponding junctions and leadthroughs, individual wires being connected to the stator 58 and its brushes for the triggering of the on-off valves 44 and 108, respectively, and for the transmission of the signals from the pressure sensors 64 and 98, respectively. However, with this will not be dealt in more detail here.

From Figs. 6, 7 and 9 it can be also seen that the holder 10 can be attached to the spindle 22 by a suitable screwing junction. For instance, another holder can be attached to the spindle 22, or simple release of the holder 10 enables maintenance and examination operation, if required. It is to be understood that the corresponding junction end of the spigot 82 and the spindle 22 is realised such that the holder 10 is screwed to the spindle 22 in the correct rotational position, so that the three channels 46, 64, 70 are aligned with corresponding bores of the spigot 82. As mentioned already, the bores in the spigot 82 are connected to the distribution channel system of the plates 90, 100, so that the channels in the spindle 22 are connected to the on-off valves 44 or 108, respectively and to the pressure sensors 64 or 98, respectively. Besides, the distribution channel system provides that the outputs of the on-off valves are connected to the individual ring chambers MK1 to MK7 in order to generate the desired pressure in these chambers and an appropriate contact pressure of the membrane 36 against the taken-up wafer 60, according to a predetermined

pressure profile in the radial direction. In Fig. 6 it can be also recognised that a central bore 170 is aligned with the central bore 110 of the upper plate 100 and also with the bore 172 in the lower plate 88, which is aligned therewith. The latter again is aligned with the central hole 68 of the membrane 36. By this arrangement, the presence of a wafer 60 on the bottom side of the membrane 36 can be detected, as has already been mentioned.